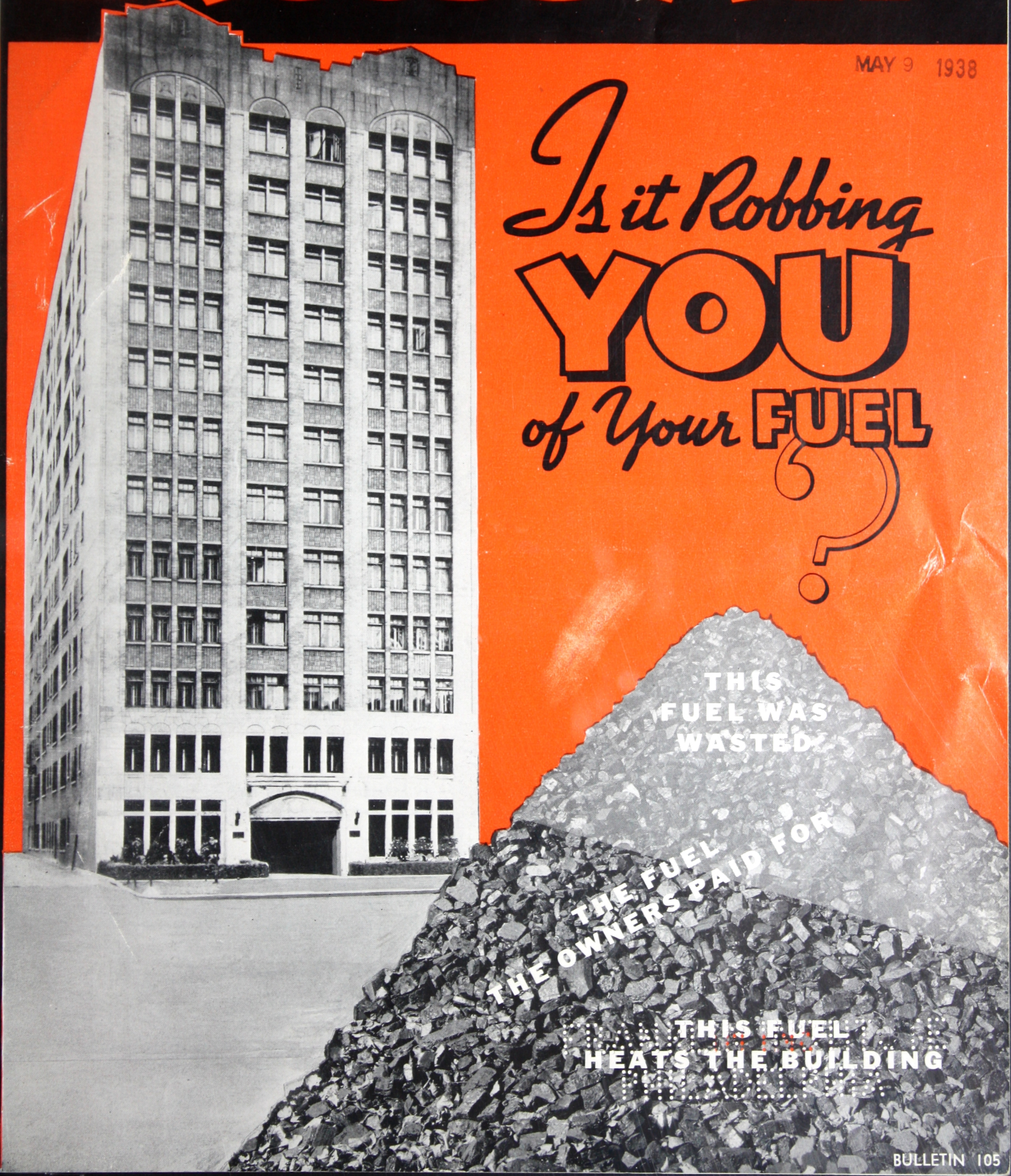
1053-5.

# Excess Air

MAY 9 1938

## Is it Robbing YOU of Your FUEL?



# Excess Air

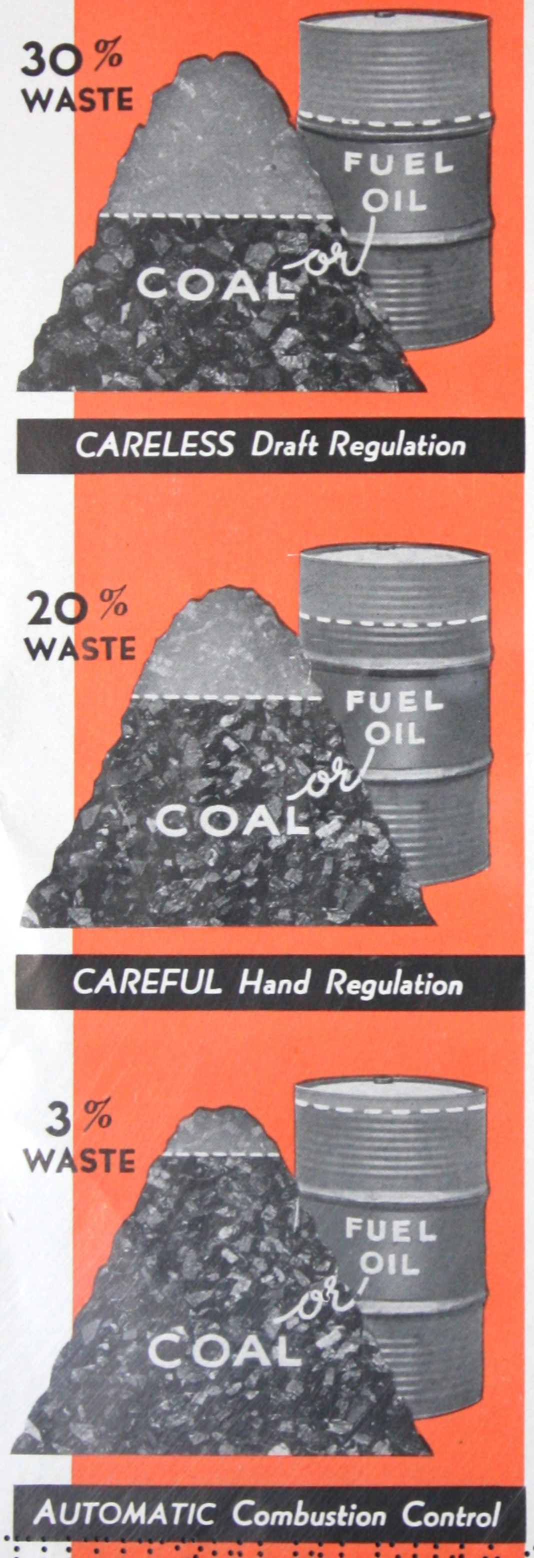



Figure 1

## Combustion Menace No. 1

EXCESS Air is the sneakthief of the boiler room. In most instances its presence isn't even suspected but it is robbing the fuel pile and the oil tank in thousands of apartment houses, hotels, and similar institutions as steadily and as surely as if this fuel were being carried off by night prowlers.

Excess air is intimately associated with draft and draft regulation. It is definitely known that 30 per cent of the fuel, whether coal, gas or oil is being wasted where there is careless hand regulation. Even with the most careful hand regulation, the loss is around 20 per cent.

There is only one known method of keeping this particular loss to a minimum and this method is *automatic draft control.*

In the following pages is given an interesting account of the relation of excess air and draft to combustion efficiency and how *automatic draft control* stops the robbing of your fuel supply.

1053-5.

# Draft

## CAN EITHER MAKE OR BREAK

# Combustion

DRAFT is the most important element in the control of combustion—and the least understood.

Combustion is a chemical process. It is the uniting of definite proportions of oxygen (air) and the carbon in the fuel. In other words only a certain amount of oxygen can be used to burn a given amount of carbon. Any additional air used will not enter into the reaction and therefore will not liberate additional heat. And this is the key to the draft problem.

When one speaks of excess air used in combustion as being costly the first thought is apt to be that "air costs nothing"—and the statement is discounted.

But here's the point in this whole matter of excess air—it isn't the value of the air that counts but the fact that when this excess air is introduced into a furnace it must be heated to stack temperature and the heat required for this is taken from the job of producing steam or hot water—and this represents pure waste.

Let us illustrate.

A room full of air (1500 cu. ft.—Fig. 2) at 60° Fahrenheit is necessary to burn *ten pounds* of coal. This air, in the furnace, after combining with the combustibles in the fuel passes up the stack at a temperature say, of 560°—having undergone a temperature rise of 500°.

Now suppose we use two roomfuls of air instead of one, or 100% excess air—twice the amount necessary for combustion. What happens? The second roomful, which cannot enter into the combustion process, is heated to 560° and drawn up the stack, carrying with it the heat that should have been absorbed by the boiler. The amount of heat thus lost would be sufficient to heat 5 rooms the same size as above from zero to a temperature of 100° Fahrenheit.


Figure 2

# 100% Excess Air in Burning 10 Lbs. of Coal Wastes Enough Heat to Heat 5 Rooms 8×15×12½ from 0° to a temperature of 100°F.

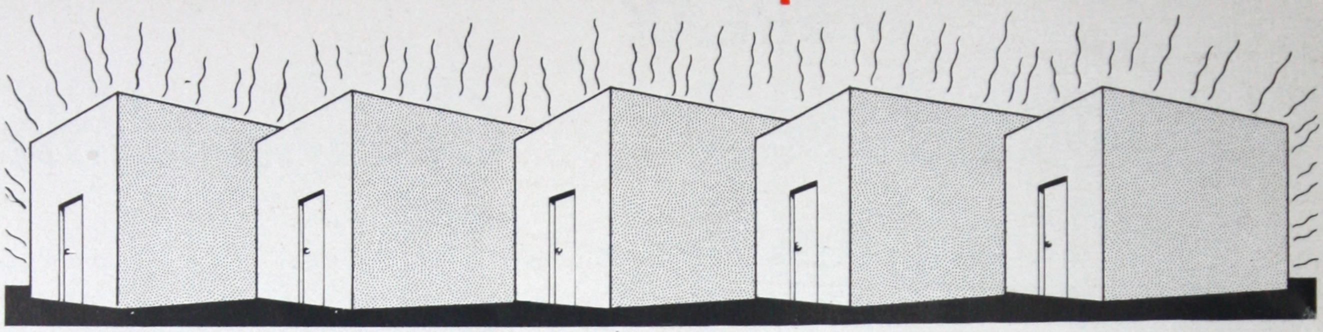


Figure 3

## Let's Look At It Another Way . . .

We have said that combustion is a chemical process. We find that in this process two atoms of oxygen always unite with one atom of carbon, forming $CO_2$, or carbon dioxide.

The air contains, roughly, 20% oxygen by volume and 80% nitrogen. If all the oxygen were consumed in burning carbon, the resulting gases would contain 20% carbon dioxide and 80% nitrogen. It is found in practice, however, that some excess air has to be used to make sure that every bit of hydro-carbon in the fuel will come in contact with sufficient oxygen for complete combustion. If 100% excess air is used, the flue gases would be diluted so that they would then contain but 10% $CO_2$.

### IT'S LIKE THIS!

(See Figure 5).

If a quart of milk contains 20% cream and we add a quart of water we will have the same *amount* of cream in the mixture but the *percentage* will be cut in half. We now have two quarts of milk and water and only 10% cream. Adding two more quarts of water, we will have four quarts of mixture with 5% cream.

Following the comparison through with our fuel and air mixture we find that theoretically perfect combustion, or the using of the exact amount of air necessary to completely consume the fuel, gives us 20% $CO_2$. Using 100% excess air or double the amount necessary for combustion cuts the $CO_2$ percentage in half, which represents a fuel loss of 5.74%. (See Fig. 6)—400% excess air reduces the $CO_2$ to 5% which means a fuel loss of 23%.

We see, therefore, that the percentage of $CO_2$ in the flue gas is a direct indication of the amount of excess air being used. Knowing this we are in position to regulate the dampers so as to give the correct amount of air or draft to raise the $CO_2$ content to a point as close as possible to that represented by perfect combustion, which is 20% for pure carbon.

In practice this 20% $CO_2$ is not possible of attainment because conditions in connection with the fuel and furnace are not perfect. In fact, *some* excess air

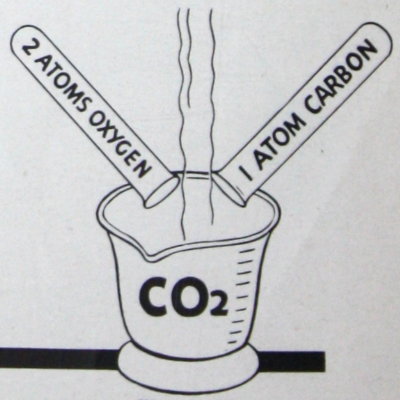



Figure 4

# It's Like This:

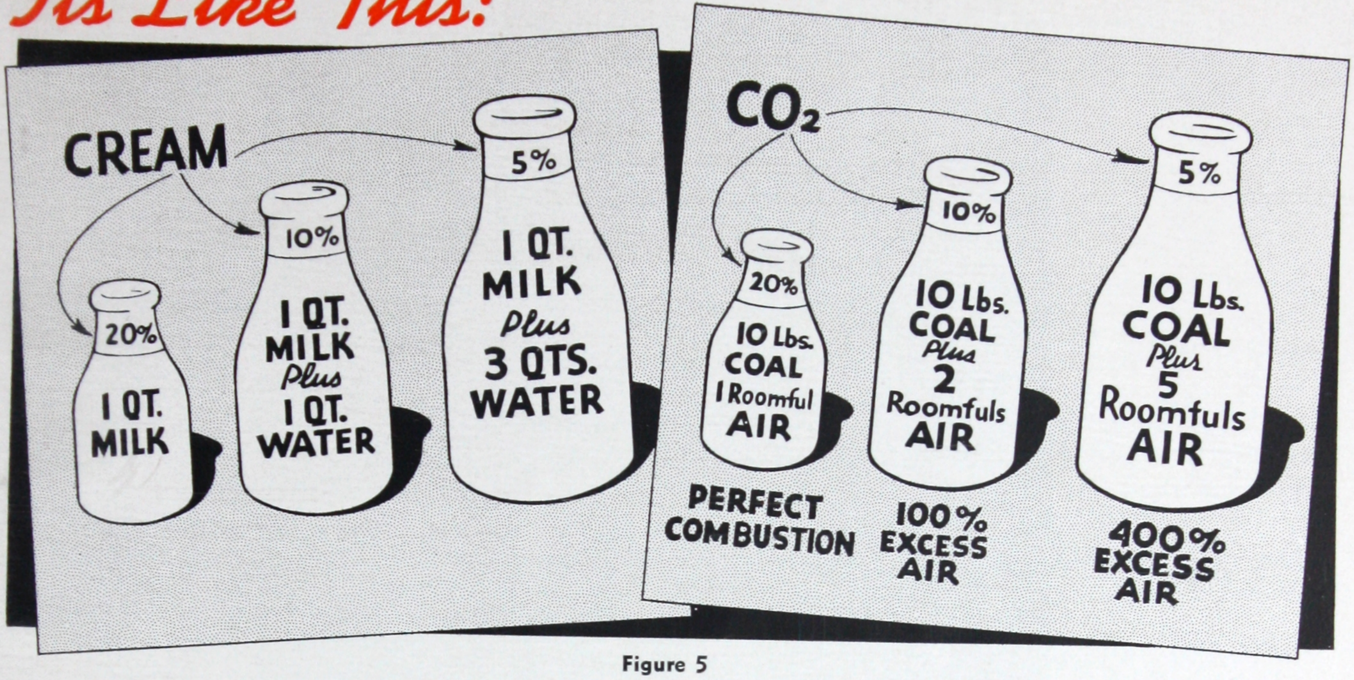



Figure 5

must be used to secure satisfactory combustion in the average furnace. Coal burned on a grate, for instance, requires about 40% excess air for best results, producing approximately 15% $CO_2$ in the flue gas, which is counted a high degree of combustion efficiency. Generally, 12 to 13% $CO_2$ is considered normal for good results.

The question now is "How can we determine the $CO_2$ percentage in our own flue gas and what can be done about it?"

And the answer is simple and positive.

The $CO_2$ content can be measured accurately by a Flue Gas Analyzer.* Knowing the $CO_2$ percentage we know how much excess air is being used and this can be reduced through regulation of the dampers until the proper draft is secured to maintain an efficient $CO_2$ percentage.

To maintain this one best draft for a given set of conditions and give visual evidence of the exact draft being used is the function of the

HAYS DRAFTROL

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*For detailed information on Flue Gas Analyzers write The Hays Corporation, Michigan City, Ind.

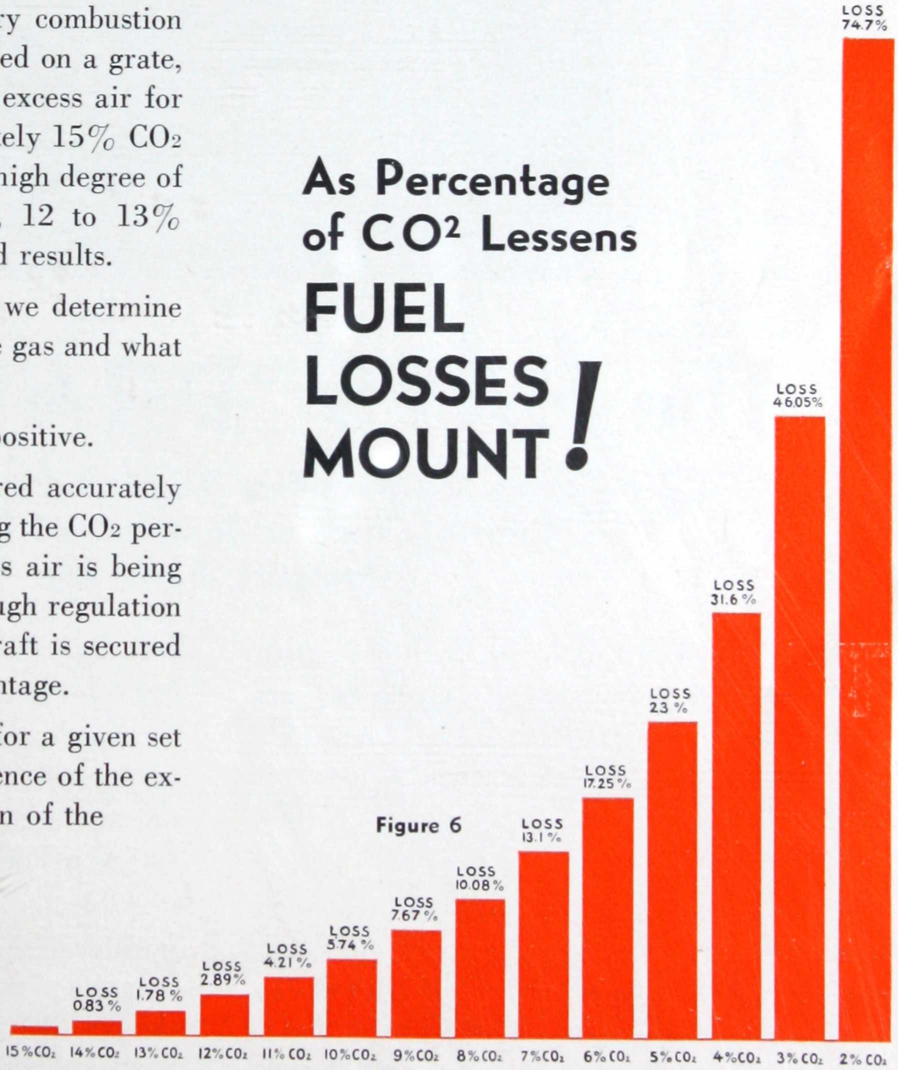



Figure 6


Figure 7

# The HAYS "DRAFTROL"

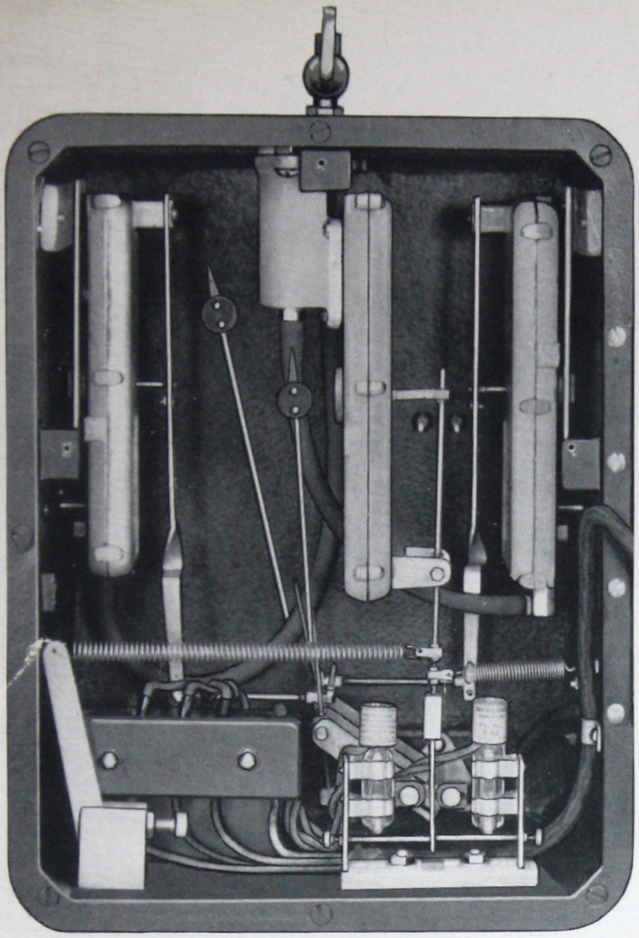
## Indicates the Over-Fire Draft and Automatically Controls Air For Combustion Through Dampers, Fans, Etc.

THE Hays Draftrol is an ingenious instrument that automatically controls the combustion chamber draft in the boiler plant. The need for an accurate and dependable means of draft control for the average sized plant prompted its development.

It is compact, ruggedly built, and the mechanism is as simple as many years of specialized engineering experience has been able to design. It employs the slack leather diaphragm that is being successfully used in some 15,000 Hays Dry Type Pointer Gages installed in some of the finest power and heating plants of the country.

This diaphragm does away entirely with liquids, floats and inverted bells. It is held in a die-cast aluminum housing for protection against dirt. Bearings are of hardened Beryllium copper.

As the pressure on the diaphragm changes, the position of the magnet arm changes, swinging the magnets to the right or to the left. When one of the magnets gets sufficiently close to the switch, it attracts an iron plate through the glass tube.



**THE INTERIOR MECHANISM** has been designed to combine strength with light weight. Friction has been reduced to a minimum and the response to pressure changes is prompt and definite. It is contained in a neat cast aluminum case measuring 10½x13¼x7⅛ inches and can be furnished for mounting flush on an instrument panel or with lugs for wall mounting. Three toggle switches are provided to permit hand operation.

Figure 8

(See Fig. 9). This draws a wire into a globule of mercury to close the electric circuit and start a motor which moves the damper and restores to normal the condition that caused the pressure variation on the membrane. The condition being corrected, the magnet is drawn away from the mercury switch, back into the neutral zone, breaking the circuit and stopping the motor. In this manner the slightest variation in pressure from that for which the gage is set causes an immediate corrective adjustment.

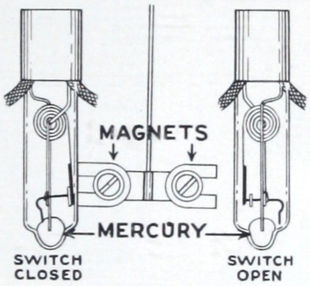



Figure 9

## APPLICATION

The Hays Draftrol maintains the proper over-fire draft by:

(a) Regulating uptake damper of natural draft boilers.
(b) Regulating ash-pit damper of forced draft boilers.
(c) Controlling fan motors of induced draft boilers.
(d) Controlling a combination of damper and fan control.

**The Hays Draftrol may be had with no indicator (Figure 7), with two scales and pointers (Figure 10), or with one scale and pointer. Several scale ranges and practically any degree of sensitivity are available.**

## RESULTS
## Secured with a
## HAYS DRAFTROL

1. Saves fuel through proper control of air through the furnace.
2. Produces high furnace temperature through elimination of excess air.
3. Produces lower stack temperature by reducing velocity of gases through the boiler, thereby giving longer time for the heat to be absorbed by the water in the boiler.
4. Eliminates fly ash and keeps heating surfaces cleaner by preventing excess draft and sudden changes in draft.
5. Saves labor because the furnace requires less personal attention and burns less fuel.

## ELECTRICAL DATA

The Hays Draftrol is designed for .25 amperes at 110 volts AC or .125 amperes at 220 volts AC, 60-cycle standard. For current other than 60-cycle a small extra charge is made. Damper operator may be either an electric power unit classified according to available torque (from 18 to 1000 foot pounds) or a hydraulic power unit operated by a solenoid valve. The latter can be furnished with coils for all standard voltages and frequencies AC or DC.


Figure 10

# The New HAYS . . .

## Sequence


Figure 11

## FURNACE DRAFT CONTROL

### Provides Automatic Draft Regulation

## PLUS

### An Exclusive Safety Feature that Prevents BLOW BACK on off-and-on Type of Oil and Gas Burners and Stokers

THE "off and on," or intermittently operated stoker, oil or gas burner, requires draft regulation even more than the continuously operated type plant.

The draft is generally higher than required during the "off" period of the stoker-fired boiler, even though it may be near normal during the "on" period. Inefficient combustion results, with consequent fuel losses. The fuel bed is often burned out during the "off" period which follows.

Some types of oil and gas burners do not shut off the air for combustion during the "off" period, although the air may be adjusted quite accurately for the "on" period. Therefore, when the burner is not operating, cold air passes through the boiler and up the stack, taking with it heat robbed from the hot boiler surfaces. The boiler then functions as a radiator and the burner must operate more frequently or at longer intervals to restore the wasted heat.

The Hays Sequence Draft Control eliminates these losses automatically, by properly regulating the combustion chamber draft to a low and efficient value during the "off" as well as the "on" periods of stoker or burner operation.

Intermittent operation of stokers, oil, and gas burners introduces a factor requiring special consideration.

It is desirable during the "starting" period that the damper in the breeching of the boiler be open to accommodate the increased volume of gases due to initial ignition of the fuel. If the damper is not open, smoke, ashes, soot and flame may be forced out at the front of the furnace into the boiler room, creating a hazardous and undesirable condition.

The Hays Sequence Control corrects this condition automatically and provides definite assurance that the damper is wide open during the "starting" period. *The stoker, oil or gas burner cannot start until the damper reaches its wide-open position to free the gases through the stack.* However, the proper control of draft during the "off" as well as the "on" period is not interfered with. From the time the starting has been completed until it is time for the stoker or burner to start again the draft is controlled accurately. It is possible to set the draft regulator to control for as low a combustion chamber draft as is necessary for efficiency without any danger of "starting" with the damper partly closed.

## CONSTRUCTION

The Hays Sequence Furnace Draft Control is comprised of two units—the control instrument and the electric power unit. The control unit consists of a set of fully enclosed, magnetically operated, non-tilting mercury switches (Figure 9); a dry-type draft measuring unit with the efficient Hays slack-leather diaphragm and a device for manual adjustment, transformer, relays, and necessary connections of the sequence unit. All of these elements except the transformer are housed in an attractive dust-tight cast-iron case with a hinged cover equipped with three toggle switches for manual operation. (See Figure 11). Case is provided with lugs for wall or column mounting. It may be had with flush panel mounting for a small additional charge.

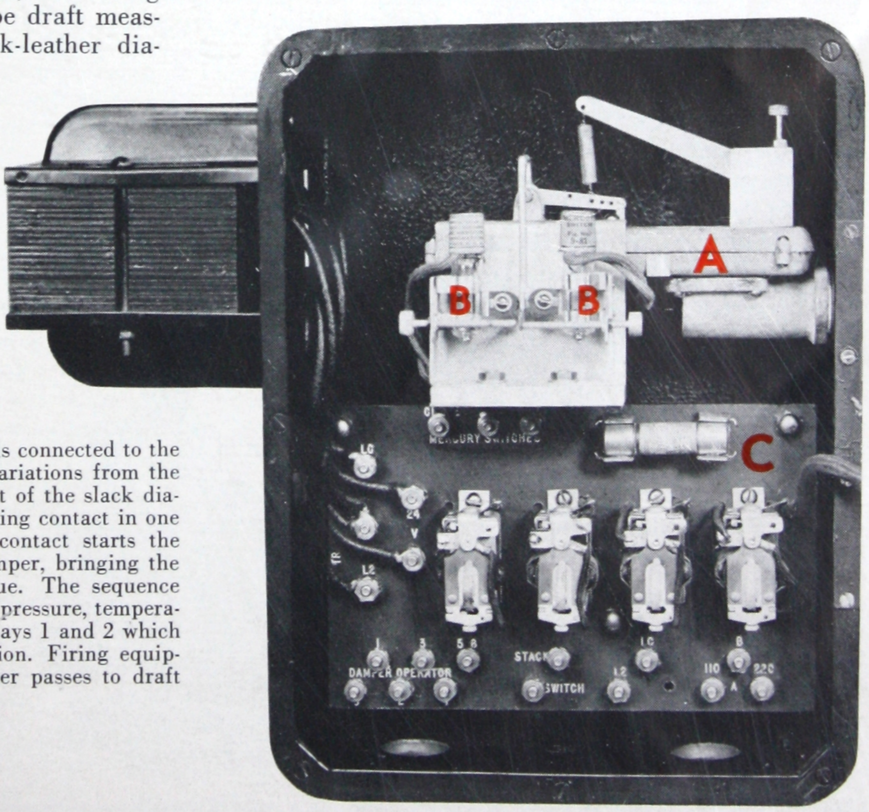
STOKERS: For Stokers an "automatic," "off," and "emergency" switch may be provided. On the "automatic" position, damper control, limit control, and sequence control are operative. On "off" position, the stoker does not operate but draft control does. On "emergency" position—if any of the automatic elements become defective or inoperative all controls are rendered inoperative, although the stoker continues to function.

OIL BURNERS: For oil-fired installations the emergency switch is not used. Instead terminals are provided for the operation of a stack switch which will hold the damper open until burner ignition has been assured.

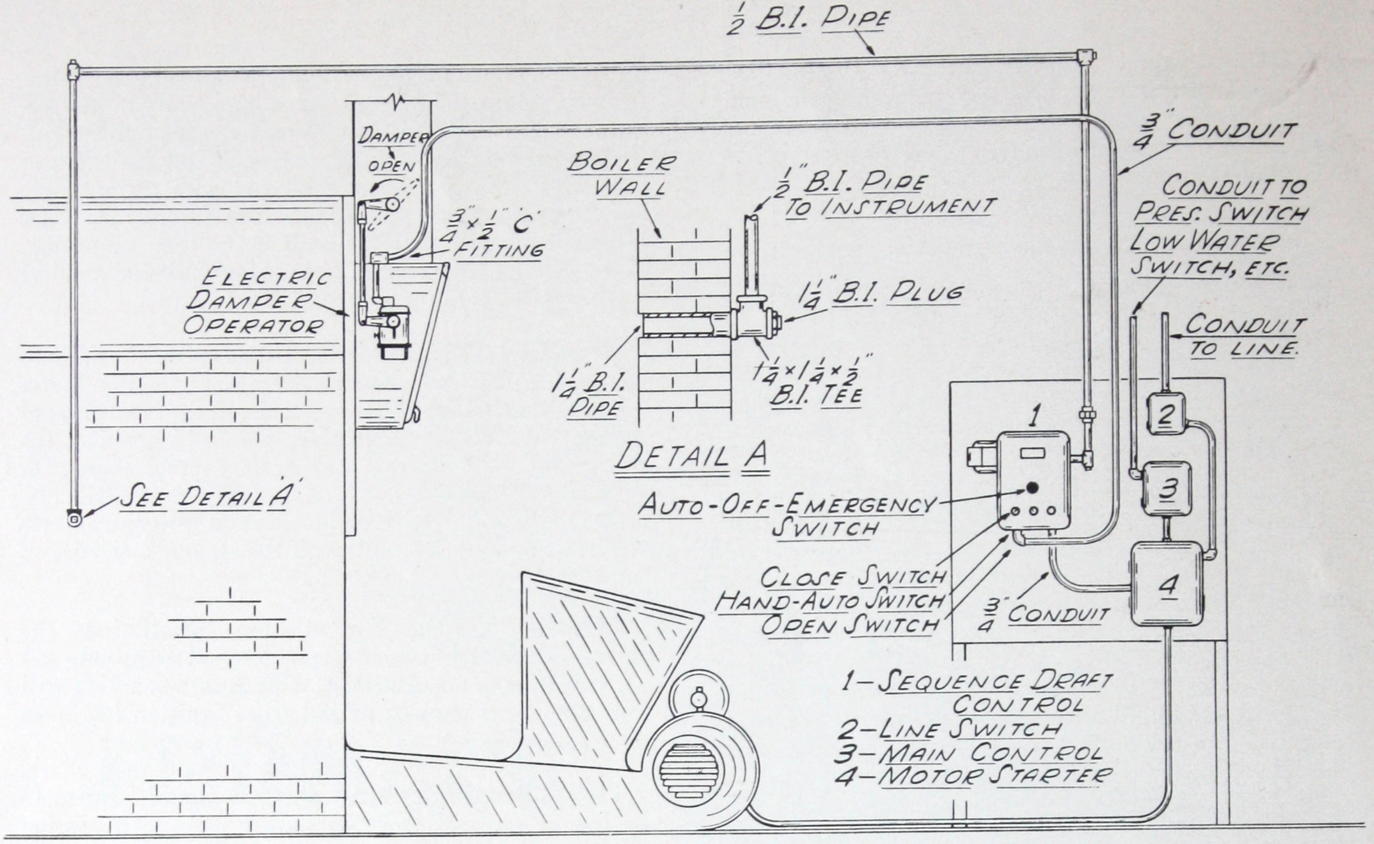
FOOLPROOF: If outlet damper should happen to be left in "closed" position during manual operation it will automatically open should burner come on, giving protection against smoking and blow back.

COMPACT: The Hays Sequence Furnace Draft Control is a marvel of compactness and simplicity. Both the sequence control unit and the regulating draft unit are housed in a case measuring $9\frac{3}{8}''$ by $12''$ by $4\frac{7}{8}''$.

***What Makes it Work . . .***




The over-fire draft from the furnace is connected to the dry-type draft measuring unit (A). Variations from the pre-determined draft cause a movement of the slack diaphragm, and this moves a magnet, making contact in one of the mercury switches (B). This contact starts the power unit which moves the outlet damper, bringing the draft back to the desired normal value. The sequence control (C) responds to the call of the pressure, temperature or main control switch, closing relays 1 and 2 which causes damper to open to its full position. Firing equipment then starts and control of damper passes to draft control unit.




## Typical Stoker Installation

**Figure 13**

Simplicity and ease of installation are features of the Hays Sequence Furnace Draft Control. The instrument may be placed near the contactor which operates the motor for the fuel-burning equipment—often on the same panel. Connections are few—one to over-fire draft control with ½-inch black iron pipe up to 75 feet distance from boiler. Two ¾-inch conduits are used for wiring—one from instrument to fuel motor starter, the other to outlet damper operator and stack switch (if used).

POWER UNIT (Figure 14): The operating mechanism of the Hays Power Unit (EA-18 or EA-50) consists of a small shaded pole type induction motor, a set of reduction gears and the necessary limit switches, all completely enclosed and oil-immersed in a weatherproof alloy case which may be mounted in any position. A suitable lever for clamping on the shaft and two female clevises for standard pipe are included. The shaded pole motors are without brushes, slip-rings, commutators or wound rotors. The gears are of high grade steel, ground and hardened for long life. These power units have manually adjustable speed regulators and the motors are reversible.

GAS OR OIL BURNERS: The hook-up for Gas or Oil Burners is similar to that for stokers except that for gas and oil burners a stack switch is employed to open the damper before a starting contact is made in the main control. Only when the damper operator has reached its full open position can the burner start, and only when burner ignition has been thoroughly established and the hot flue gases reach the stack switch will the damper close. From then on the automatic draft regulator takes control to maintain the desired over-fire draft.

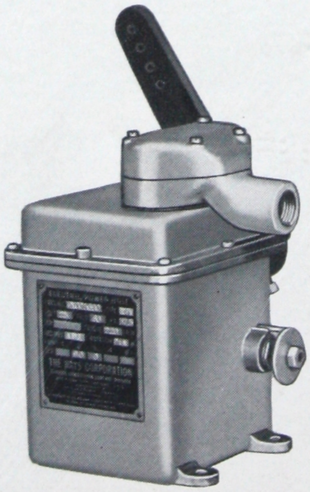


**Figure 14**

ELECTRICAL DATA: The Hays Sequence Furnace Draft Control is designed for .25 amperes at 110 volts A. C. or .125 amperes at 220 volts A. C., 60-cycle standard. For frequencies other than 60 cycles, and for voltages above 230 volts, a small extra charge is made.

The damper operator is a low voltage variable speed reversible, totally enclosed oil-immersed motor. The damper operator furnished with Type DEL-S18 Control has an available torque of 18 foot pounds. The damper operator furnished with Type DEL-S50 Control has an available torque of 50 foot pounds.

The Hays Sequence Control is not offered for direct current.

# WHY ORDINARY CONTROL IS UNSATISFACTORY

The customary attempts to control furnace draft are far from satisfactory. They are characterized by serious fuel losses and considerable inconvenience.

Ordinary methods are as follows:

1.—Manual control of boiler.

2.—Reducing stack capacity by opening dampers in dead boilers or clean-out doors in base of stack.

3.—Automatic regulation of breeching draft near stack.

**Manual Control of Boilers.** We have mentioned manual control of boilers first in our list of methods because that is the practice most plants attempt to follow. As a rule, however, in starting out with the plant one of the first things the owners insist upon, in their efforts to reduce first cost, is omitting all the Draft Gages, $CO_2$ Recorders, Feed Water Meters, etc., which the architects and engineers have specified for the operation of the plant.

It is only through the continuous and intelligent use of these instruments that manual control of the boiler plant even has a chance to be successful. Without instruments the fireman is left with only a coal shovel and a steam gage with which to operate his plant and his job becomes one of keeping furnaces full of fuel rather than empty of excess air. Another factor that prevents manual control from being successful is the fact that as a rule the fireman is not in the boiler room continuously since he usually has many other duties to attend to. For manual control to be successful with minimum fuel consumption, all the necessary instruments must be provided for his guidance and he must remain at his post continuously, giving the closest attention to the draft and changing furnace conditions. It is unfortunate that so many plants have neither the instruments nor the close attention and are losing vast sums of money as a result.

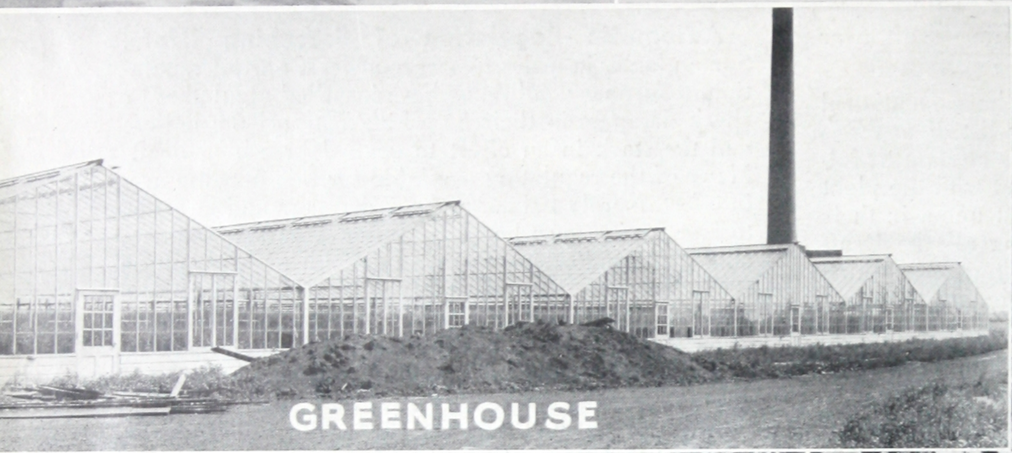
**Reducing Stack Capacity With Clean-Out Doors.** Many attempts are made to compensate for excessive stack capacity by leaving dampers open in dead boilers or by opening the clean-out doors in the stack. This method of controlling the draft is partly effective, but, of course, no compensation is secured for variations in atmospheric conditions, winds across the top of the stack, etc., which affect the combustion conditions in the furnace appreciably. This method of control is also objectionable because it produces a drafty boiler room and corridors leading to the boiler room. The principal objection, of course, is that this method of control of draft does not produce the maximum fuel saving possible and leaves most of the benefits still to be secured by manual control of the boiler dampers.

**Automatic Regulation of Breeching Draft.** Some plants, in order to secure at least partial regulation of furnace conditions, have installed regulators or check dampers in their breeching between the boilers and the stack in an effort to control breeching draft. Many of the regulators available for this purpose are, in effect, merely balanced check dampers and in order to be effective must be of a size that requires considerable space and often presents a difficult problem of installation. Dampers of this type, due to the fact that they are affected by atmospheric changes, may be more efficient than attempting draft control through opening of dampers on dead boilers and the opening of clean-out doors in the stack. However, they take vast quantities of air out of the boiler room with which to kill the draft and this results either in a bottled up boiler room or serious waste from the leakage of unnecessary large quantities of cold outside air into the boiler room. In winter weather especially it is a very expensive method of control and one which is unpopular with firemen due to the uncomfortable dangerous drafts which are created in the boiler room.

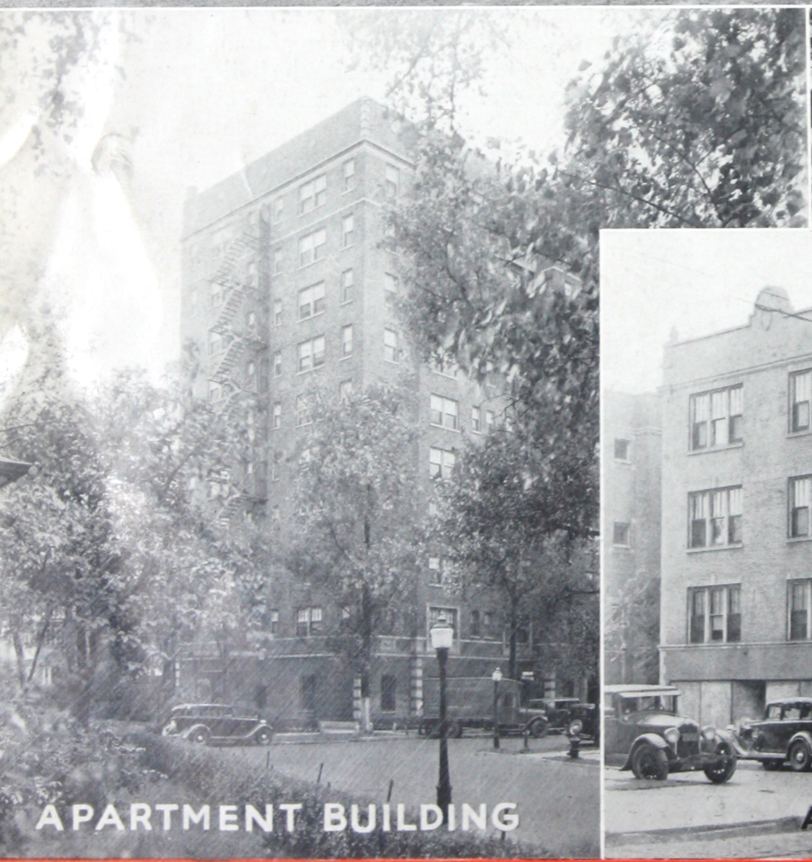
*The correct place to control the draft is in the furnace itself for it is there that the combustion process is taking place.* Breeching draft control cannot insure the maintenance of constant furnace draft. Fuel bed conditions and the resistance to flow of air through the fuel are the determining factors in securing proper furnace draft. It is obvious, where two or more boilers are on one breeching, that with a constant breeching draft the fire that is thinnest will get the most air while the thickest fire will smolder due to too little air. The boiler that is farthest from the stack will also, as a rule, get less air, fuel bed conditions in all boilers being the same. It is conceded with authorities on combustion problems that to get the best results, draft in each furnace must be controlled in accordance with furnace and fuel bed conditions within that particular furnace.


CLUB BUILDING

LAUNDRY


GREENHOUSE


APARTMENT BUILDING


APARTMENT BUILDING

APARTMENT AND STORE BUILDING

TYPICAL BUILDINGS THAT ARE SAVING FUEL THROUGH AUTOMATIC DRAFT CONTROL